

Effect of Filtering Ozone-Polluted Dryer Air Through Activated Charcoal on the Flavor of Foam Spray-Dried Whole Milk

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Abstract

To determine whether the flavor of dried milk manufactured with ozone-polluted air could be improved by filtering the air through activated charcoal, a series of foam spray-dried whole milks were manufactured using, alternately in each experiment, standard cellulose dust filters and activated charcoal filters in the dryer air inlet.

Using cellulose filters, ozone levels of air entering the dryer were 4-17 parts per billion (average 8 ppb) and powder flavor 0.6-4.0 flavor points (average 2.0 points on a 10-point scale) lower than their parent concentrates. Using charcoal filters, ozone levels of air entering the dryer were zero, and powder flavor varied from 0.2 point higher to 0.7 point lower (average 0.1 point lower) than concentrates.

Ozone levels as low as 6 parts per billion, if added to charcoal-purified air, had a definitely damaging effect on the powder's flavor. Powder manufactured in ozone-free air, and cooled before exposure, retained its high flavor quality during moderate subsequent exposure to polluted air.

The flavor quality of milk powders manufactured in our Dairy Products Laboratory has varied seasonally for years (3). Powders made during cold weather have been consistently good, while those made during the hot-weather season have been variable in quality. Moreover, the excellent flavor quality of powders made during a period of low background levels of ozone could be seriously damaged by adding ozone to the dryer air in concentrations reported by others as occurring naturally in the Washington, D.C., area during the summer.

Our earlier work inferentially associated the hot-weather flavor problem with ozone in polluted air. Ozone decomposes to some extent on most surfaces. Activated charcoal has been used to provide ozone-free air for the study

of plant growth (5). Our study was initiated to determine if the variable flavor of dried milks manufactured during the hot-weather season could be improved by filtering incoming air for the dryer through activated charcoal. We conducted a series of experiments during a period of relatively high background levels of ozone. In each experiment, foam-dried whole milks were manufactured using, alternately, regular and activated charcoal filters. Ozone levels within the dryer were measured throughout the experiment and the powders evaluated organoleptically by a trained taste panel.

Materials and Methods

Foam spray-dried milks were prepared from low-heat whole milk (15 sec at 77 C), using 57 liters/minute of nitrogen for foaming, as previously described (2). The powders were cooled with liquid nitrogen approximately to room temperature before exposure to plant air outside the dryer (1). The data for Tables 1 and 2 were obtained in the following manner. With the standard cellulose dust filters (American Air Filter Corp.,¹ Louisville, Ky.) in place, milk powder from 11 kg of concentrate was discarded and powder Sample A, without screening with a minimum of air exposure, was collected directly in a jar, capped until the powder was used for reconstituting milk. The cellulose filters were replaced with activated charcoal filters (Model FMD, Barnabey-Cheney, Columbus, Ohio), powder from 33 kg of concentrate was discarded and powder from 11 kg of concentrate was collected in a milk can after which powder Sample B-1 was collected directly in a jar. Powder in the capped milk can, after holding 20-25 min, was screened in the polluted air and then stored in a capped jar (Sample B-2) pending reconstitution. The charcoal filters were replaced with cellulose filters and powder Sample C collected directly in a jar after discarding the product from 33 kg of milk concentrate.

¹ Mention of brand or firm names does not constitute an endorsement by the Department of Agriculture over others of a similar nature not mentioned.

TABLE 1. Effect of removing ozone from dryer air by activated charcoal filters on flavor of foam spray-dried whole milk.

Experiment no.	Milk concentrate	Milk powder			
		Cellulose inlet air filters		Activated charcoal inlet air filters	
		Ozone level ^a	Flavor score ^a	Ozone level	Flavor score
		(ppb)		(ppb)	
1	37.0	7	34.9	0	37.0
2	37.4	5	36.7	0	37.3
3	37.4	17	33.4	0	36.7
4	37.5	6	36.0	0	37.3
5	37.1	11	34.2	0	37.3
6	37.3	6	35.4	0	37.2
7	37.3	4	36.7	0	37.3

^a Average value for two samples, one of which was manufactured at the beginning and one at the end of each experiment.

During filter changes which took 10-15 min, the concentrate fed into the dryer was replaced with water. Measurements of ozone in the incoming dryer air were made as previously described (3), with the inclusion of a chromium trioxide scrubber for removing sulfur dioxide. Milks were reconstituted from the powder samples and refrigerated overnight. The flavor of these milks was then evaluated by a trained taste panel using a 10-point scoring range of 31-40 (4). All powders were tasted in duplicate. Milk concentrate samples taken at the beginning and end of each experiment were tasted singly and their scores, which closely agreed, averaged for Tables 1 and 2.

For the data of Table 3, four milk powders were manufactured in each experiment. Powder A was made with the addition of ozone to the incoming dryer air between the charcoal filters and the blower (3). Powder B was made similarly to A, but with a lower level of added ozone. Powder C was also made using charcoal filters, but with no added ozone. Powder D was made with the standard cellulose dust filters and no added ozone. As before, sufficient powder was discarded between each collection to clear the dryer of the preceding powder. These powders, along with milk concentrate samples collected at the beginning and end of each experiment, were evaluated as described above.

Results

The data of Table 1 show a marked improvement in flavor quality when the incoming ozone-

TABLE 2. Effect of subsequent exposure to polluted air on flavor of foam spray-dried whole milk manufactured in ozone-free air.

Experiment no.	Milk concentrate	Unexposed powder ^a			
		Ozone level in charcoal-purified air		Exposed powder ^b	
		Ozone level	Flavor score	Ozone level in polluted plant air	Flavor score
		(ppb)		(ppb)	
1	37.0	0	37.0	7	37.0
2	37.4	0	37.3	5	37.6
3	37.4	0	36.7	17	36.7
4	37.5	0	37.3	6	37.1
5	37.1	0	37.3	11	37.3

^a Cooled to about room temperature in liquid-nitrogen vapor and collected directly in bottles without screening with a minimum of air exposure.

^b Cooled to about room temperature in liquid-nitrogen vapor, then collected in milk cans, held for about 20 min, and screened in polluted air.

polluted dryer air is filtered through activated charcoal. The effect of the drying process on flavor quality is measured here by comparing the flavor score of each milk reconstituted from a powder with that from the powder's concentrate. These experiments were conducted during a two-month summer period. With the regular dust filters in place, the ozone level in the dryer (measured before the heater) varied from 4 to 17 ppb. Under these conditions, from 0.6 to 4.0 (average 2.0) flavor points were lost in the drying process. In contrast, with the charcoal filters in place the ozone levels were reduced to zero and the powder flavor scores varied from 0.2 higher to 0.7 lower (average 0.1 lower) than the concentrates.

Table 2 shows that if the powder is cooled before exposure to the polluted air, the subsequent exposure incident to screening and packaging does not have an adverse effect for the pollution levels of these experiments.

By the addition of ozone to charcoal-purified air (Table 3) it is evident that ozone alone is sufficient to damage the flavor of milk powder.

Discussion

The data of Table 1 show a remarkable improvement in the flavor of dried whole milk when ozone-polluted air is filtered through activated charcoal. When manufactured in air naturally polluted with ozone, the powders had

TABLE 3. Comparative effects of ozone in naturally and artificially contaminated dryer airs on flavor of foam spray-dried whole milk.

Experiment no.	Milk concentrate Flavor score	Milk powder			
		Cellulose inlet air filters		Activated charcoal inlet air filters	
		Ozone level	Flavor score	Ozone level ^a	Flavor score
		(ppb)		(ppb)	
1	37.3	6(D) ^b	35.4	0(C) 2(B) 10(A)	37.2 36.7 33.8
2	37.3	4(D)	36.7	0(C) 6(B) 12(A)	37.3 36.1 35.0

^a Positive ozone levels were obtained by adding ozone to the incoming dryer air at a point between the charcoal filters and the blower.

^b Letters in parentheses designate procedures described in Materials and Methods section of paper.

a characteristic off flavor. This flavor defect had the same character as that which we have encountered for a number of years during the hot-weather season and which we were able to reproduce by adding ozone to the incoming dryer air (3). Milk dried in ozone-free air, obtained by filtering the polluted air through activated charcoal, had a flavor which could not be distinguished from that of its concentrate in six of seven experiments. In one instance, a borderline flavor loss of 0.7 point occurred when the plant air had an ozone concentration of 17 ppb.

To test the effect of powder exposure to the outside air, comparisons were made between powders collected directly in jars and samples of the same powders with the greater exposures attendant to holding and screening. Under the pollution conditions existing during these tests there was no adverse effect associated with the longer air exposure (Table 2). It remains to be seen whether this will be found, also, in more highly contaminated air. In all of these experiments the powders were cooled before exposure to the outside air. Further tests will be made to determine if this cooling step is necessary for maintaining high quality initial flavor.

When it was found that ozone concentrations in nonpurified plant air as low as 6 ppb produced substantial flavor damage, the question arose whether pollutants other than ozone might be involved. The data of Table 3 show that low levels of ozone, in otherwise pure air, do substantially damage the flavor of dried milk. While other pollutants may have some damaging effect, ozone is probably the major contributor to the flavor damage encountered

during these experiments when milk was dried with naturally polluted air. Whether or not other compounds are involved, filtration of polluted incoming dryer air through activated charcoal is effective in improving the flavor of spray-dried whole milk.

Our earlier work (3) showed that both dried skimmilks and dried whole milks, whether foamed or nonfoamed, were subject to flavor damage when manufactured in the presence of ozone, but that foam spray-dried whole milk was the most severely damaged by this air pollutant. Whereas, this paper is concerned only with foam spray-dried whole milk, it is expected that the other products, as well, would be protected from the damaging effects of ozone-polluted air by filtering the air through activated charcoal.

References

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